2
Hurting and Healing Characters

As to diseases make a habit of two things—to help, or at least, to do no harm.

Hippocrates
Epidemics

HUMANOID. Serial No. 81-H-B-27. The Perfect Mechanical. "To Serve and Obey, and Guard Men from Harm."

Jack Williamson
"With Folded Hands" (1947)

Humans generally prefer to be healthy and without pain. We can increase the odds of staying that way by eating proper amounts of nutritious foods, getting enough exercise, and not engaging in optional behavior that is likely to harm us. Nonetheless we cannot entirely avoid illness or injury, and barring major medical advances we will all ultimately age and die.

Risk is an intrinsic part of human existence, present in even the simplest decisions of everyday life. Despite the possibility of food poisoning, we must still eat food because the ultimate results of starving are worse and far more certain to cause harm. No matter how carefully we drive there is always the chance a runaway truck could smash into us. As Hippocrates knew all too well, every time a physician prescribes a new medication or performs an operation there is a nonzero chance of making the patient worse. An ongoing goal of medical practice is to find new ways to tilt this "risk-benefit ratio" as far away as possible from the risk side and toward the benefit one.

Even just enjoying life and trying to accomplish any goal involves some degree of physical or psychological risk, including that of failure. Whether choosing how to spend our money or who to marry there is always the possibility of making a wrong decision, yet we do it in the hope that things will work out well and our lives will be improved. After getting out of bed in the morning a person might slip in the shower and break a leg, catch a cold from a fellow employee at work, or be hit in the head by a foul ball at a nighttime

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baseball game. But if that individual elects to stay in bed he or she will also accomplish and enjoy much less than by taking such risks.

Likewise, astronauts and cosmonauts know how risky their ventures into space are. Nonetheless they still put their lives on the line and, as Chap. 3 will describe, in a few cases have lost them in pursuit of what the typical science fiction reader will agree is a noble goal. A world such as that depicted in Jack Williamson's classic novelette "With Folded Hands" (1947) where *all* avoidable pain and risk is eliminated by overprotective robots might increase how long we live, but at the cost of turning life into mere existence.

Science fiction excels at presenting characters who either willingly or are forced to take risks in imaginatively original settings. Protagonists may encounter dangers no human has ever encountered before as well as deal with new ideas that challenge their preexisting worldviews and conceptions. When reading or watching those characters' adventures we have the opportunity to identify with their struggles, share their pain and joys, and live for a time in a world with more thrills, tragedies, and triumphs than our own.

But while many might enjoy seeing characters persevere and win against overwhelming odds in the movie *Independence Day* (1996) or Larry Niven and Jerry Pournelle's *Footfall* (1985), fewer would wish to actually live through the devastating alien invasions those works depict. In a story the author is in complete control of what happens, and however many imaginary millions are injured or killed in it we readers are left physically unharmed. But in the real world success depends on what *we* do, with no guarantee of survival or a "respawn" button to use after failure. Thus, there can be a huge gap between how dangerous we want our own lives to be and those that characters in science fiction works live. We hope that flesh-and-blood astronauts have space missions that are as safe as possible, while a story in which fictional ones were not subjected to terrible dangers would be boring.

Besides those still restricted to science fiction such as falling into a black hole or teleportation accidents, there are many realistic ways to inflict or threaten to inflict sickness, injury, and other medical mayhem on characters before (perhaps) healing them. However, science fiction may be less than completely accurate in how it shows them being hurt or depicting how medical care is delivered and healthcare providers act. A little "fudging" with medical details might be justified in the interests of dramatic license and moving the story's plot along. On the other hand, a science fiction work would be weakened if it contains an egregious medical error that is *not* needed for story purposes. This chapter will suggest ways to inject at least some degree of realistic medicine into science fiction.

2.1 Common Illnesses

Murphy's Law applies to every part of our bodies. So many things can go wrong with it that not even the most educated and experienced physician could know all their details by rote. Those many diseases and dysfunctions can be grouped into a smaller number of general categories. These include infections, autoimmune diseases (one in which the body attacks its own tissues), disorders of organ function, metabolic abnormalities (e.g. reduced production of insulin in Type 1 diabetes mellitus), nutritional deficiencies (such as those associated with lack of specific vitamins), "wear-and-tear" damage to body parts (e.g. the cartilage in our knees), diseases that directly damage organs and tissues, processes that target nerves and the inner lining of blood vessels, genetic disorders, cancer, and many more.

2.1.1 Common Causes of Death

Some diseases and injuries may run only a short course leading to complete recovery. Other types cannot be completely cured and cause chronic disability. Some are so serious they ultimately prove fatal. The most common causes of death differ based on age. Statistics for 2010 from the Centers for Disease Control and Prevention in the United States show that babies less than 1 year old are most likely to die of "congenital anomalies"—abnormalities in development—with premature birth being the second most common cause of death [1]. Between the ages of 1 and 44 years old the most common cause of death is not any disease, but accidents. The second most common cause of death between the ages 1–14 and 35–44 is cancer, while the second and third most common causes between ages 15 and 34 are homicide and suicide. It is only after age 45 that actual, acquired diseases take the top spots as causes of death. Between the ages of 45 and 64 cancer is the most common cause of death, followed by heart disease. After age 65 those two diseases reverse their order, with heart disease being the leading cause of death followed by cancer.

Babies and children are particularly vulnerable to infections. At the beginning of the twentieth century pneumonia, tuberculosis, enteritis (infections involving the intestines), and other infectious diseases were the most common cause of death in that age range. Improvements in sanitation and hygiene, better nutrition, and development of antibiotics and vaccines have dramatically lowered mortality during infancy and childhood. In 1900 30.4 % of all deaths in the United States occurred in children less than 5 years old, while near the end of the twentieth century in 1997 that rate had fallen to 1.4 % [2].

2.1.2 Cardiovascular Disease

The high rates of homicide and suicide in the 15–34 year age range are associated with injuries to the body that will be discussed in the next section. In older adults both heart disease alone and the more general category of cardiovascular disease, which also includes problems with blood vessels, are major causes of morbidity and mortality. The heart and its valves can be damaged due to gradual or sudden loss of their blood and oxygen supplies, infections, inflammation, infiltration by materials that reduce their ability to function properly, "wear-and-tear" from aging, exposure to toxic substances, tumors, etc. The heart's complex electrical system can "short circuit" in a variety of ways that can significantly reduce cardiac function and potentially lead to death.

Blood vessels become "stiffer" with age, thus contributing to development of high blood pressure, or "hypertension." The latter in turn can put increased strain on the heart and damage it as well as other organs (e.g. the brain and kidneys). Sections of major arteries such as the aorta may enlarge and even rupture, and smaller arteries can become inflamed. Blood clots ("thrombi") can form in both arteries and veins. A thrombus can potentially travel through those blood vessels ("embolize," with that mobile blood clot being called an "embolus") to distant parts of the body where it can cause damage by blocking the blood supply to important organs.

For example, an arterial embolus going to the brain can cause either a significant temporary reduction of blood to part of that organ (a "transient ischemic attack," or TIA), or permanent damage (a "cerebrovascular accident," or CVA—more commonly called a "stroke"). One or more emboli passing through the venous system to the right side of the heart can lodge in the pulmonary arterial system in the lungs, a "pulmonary embolism." This reduces the affected sections of the lungs' ability to exchange oxygen and carbon dioxide. Depending on how much of one or both lungs are involved, the effects could include a person experiencing only mild shortness of breath, or dying due to inability to breathe effectively.

Arteries in many different parts of the body can develop "atherosclerosis" [3]. This process involves injury to the inner lining (intima) of the aorta and smaller arteries. Damage inside those arteries can progress to development of raised areas called "plaques." High blood pressure, elevated cholesterol (particularly of a type called "low-density lipoprotein," or LDL), diabetes, and smoking are all risk factors for developing atherosclerosis. Atherosclerotic plaques typically start out as yellowish fatty streaks along the intima and can be present as early as age 10. Over a period of years damage to the artery could increase due to inflammation and accumulation of both muscle cells and white blood cells containing fat ("foam cells") within the intima.

The most advanced stage of atherosclerosis is the "fibrous plaque." This is a white, raised area that at least partly blocks off the artery itself. Fibrous plaques are usually fairly soft. However, especially in older adults and those with diabetes those plaques can also accumulate calcium and become hard and rock-like.

Atherosclerosis in the arteries supplying the heart causes "coronary artery disease," or CAD. If an atherosclerotic plaque blocks off most of the interior ("lumen") of a coronary artery, the area of the heart supplied by that artery may not receive as much blood and oxygen as it needs either when demand for them is higher with exercise or even when a person is at rest. The resulting "myocardial ischemia" may cause various symptoms. A common one is "angina pectoris," typically felt as a pressure or "heavy" sensation beneath the sternum (breastbone). This "chest pain" may spread into the neck, jaw, or either arm (most typically the inner side of the left arm). It may also be felt as "indigestion" and accompanied by other symptoms such as shortness of breath, sweating, nausea, or lightheadedness.

Angina may be "stable," occurring in a reasonably predictable pattern in terms of how often it occurs, how long it lasts (typically only a few minutes), and when it happens (e.g. occurring with exertion and relieved by rest.) As one or more fixed blockages in the coronary arteries become severe, leaving only a relatively small opening for blood to go through, angina may occur at rest or wake a person up at night. Also, if the pattern of angina changes in some way—for example, occurring at rest when before it occurred only with exertion—it comes "unstable angina." The latter can be a warning that a person is at increased risk of an even more serious event—a "myocardial infarction," "MI," or "heart attack." This occurs when an area of the heart (most commonly part of the left ventricle) is deprived of blood long enough (about 20–25 min) that permanent damage to it starts to occur. This is most commonly due to sudden rupture of a fibrous plaque, resulting in rapid formation of a blood clot and partial or complete occlusion of the artery at that location. Such plaques may originally have only mildly blocked the artery and produced no prior symptoms such as angina. In fact, an MI may be the first sign that a person even has CAD.

An individual having an MI may have no symptoms, vague nonspecific symptoms such as a feeling of indigestion that are not recognized as coming from the heart, more "classic" ones such as prolonged chest pain (although about one-third of people do not have it), or even sudden collapse and death. An MI may be so severe that it could at least temporarily impair a person's heart function and/or permanently damage it enough that the heart cannot supply an adequate amount of blood to the rest of the body. This can be associated with problems such as severe shortness of breath, a dangerous drop in blood pressure, lightheadedness and loss of consciousness, or even prove fatal.

However, the most immediate risk of an MI is that the heart can become electrically unstable even if only a relatively small part of it is deprived of blood or damaged. Individuals with an acute MI may experience "sudden death" due to development of a life-threatening abnormal heart rhythm (arrhythmia), often within the first hour after the MI occurs. One of these arrhythmias, ventricular tachycardia (VT), is caused by electrical impulses arising from a ventricle at a faster rate than the ones at their normal point of origin, the sinus node. VT can produce a heart rate as low as 110 beats per minute, with a person usually having only mild or no symptoms with that rate. However, VT can also occur at a rate as high as 300 beats per minute or more—too fast for blood to move in and out of the heart to supply the rest of the body or generate a detectable pulse.

An MI can also cause an even deadlier arrhythmia, ventricular fibrillation (VF) [4]. With VF the ventricle is producing impulses that are so frequent and chaotic (e.g. 400–500 times per minutes) that the heart just "quivers," with no effective pumping action at all. If either VF or the faster types of VT are not treated within minutes the person can suffer permanent brain damage or even die due to lack of blood to that organ and the rest of their body.

Both VT and VF are diagnosed by their characteristic patterns of the heart's electrical activity on an electrocardiographic monitor or printed electrocardiogram ("ECG" or "EKG"). They can be treated by delivering one or more electrical shocks to the chest from a "defibrillator." In hospitals and many other settings a monitor and defibrillator are combined into a single device. An "automated external defibrillator" does not include the monitor but is programmed to detect ventricular tachycardia or ventricular fibrillation and deliver an electric shock if indicated. Both types of defibrillator require that two adhesive pads or, as an alternative with a monitor-defibrillator unit, a pair of paddles be placed firmly on the patient's bare chest to deliver a shock. Most commonly one patch or paddle is placed just to the right of the upper sternum (breastbone) while the second is placed near the lower left edge of the rib cage. The person delivering the shocks and any helpers need to stay out of direct contact with the patient to avoid receiving part of that "jolt" too—hence the "Clear!" and other phrases used to warn others away before giving the shock.

The full details of "cardiopulmonary resuscitation," including chest compressions, administering medications, supporting a person's respirations with tubes placed into the throat, etc. are too involved to go into here. I will, however, return to this subject later in this chapter to critique how these procedures are sometimes portrayed in science fiction and elsewhere.

2.1.3 Infections

The drama of a character having an MI or the idea of a weakened or aged person having to stay in the microgravity of space because the "heart wouldn't take" coming back to Earth's gravity have a valid place in science fiction (although how those risks are portrayed may not be entirely accurate). Similarly, inflicting a serious infectious disease on someone or an entire population can be used to create dramatic situations in science fiction.

However, such characters are unlikely to be depicted as suffering from common infections such as colds, or a very minor case of cellulitis (a bacterial infection of the skin, associated with redness and perhaps swelling) associated with a hangnail. Instead they seem more likely to encounter new, exotic infectious diseases, whose mortality rate might make that of the medieval Black Death and the modern-day Ebola virus appear closer to that of a bad case of the sniffles by comparison. Those horrific infections in science fiction may be terrestrial in origin, such as the Blue Death in C. L. Moore's and Henry Kuttner's "Vintage Season" (1946), or in George R. Stewart's 1949 novel *Earth Abides*. Alternatively the infection might be of extraterrestrial origin, such as in Michael Crichton's 1969 novel (and later movie) *The Andromeda Strain* or the 1953 television serial *The Quatermass Experiment*. In some classic works, like H. G. Wells's *The War of the Worlds* (1898) or several of Ray Bradbury's *The Martian Chronicles* stories, the direction of infection is reversed, with human pathogens killing aliens.

The possibility of a widespread epidemic killing large numbers of people is, unfortunately, firmly rooted in reality. Whether the infectious organism in a science fiction work develops naturally, or is either accidentally or deliberately unleashed after misguided scientists develop it, there are historical analogs. The aforementioned Black Death, mass casualties in Native American groups due to their lack of immunity to diseases such as smallpox carried by European explorers after the first voyages of Christopher Columbus, the 1918 influenza pandemic that infected an estimated 500 million people (about 30 % of the entire world's population) and killed up to 50 million of them, and more recent widespread infections involving the human immunodeficiency virus (HIV), the causative agent for AIDS (acquired immunodeficiency syndrome), and Ebola virus, are all too real [5, 6].

However, where science fiction tends to deviate from realism is by exaggerating the numbers of victims and the specific effects of the diseases. Based on the total number of people who died, the deadliest pandemic in history was the 1918 influenza pandemic. It killed about 3 % of everyone living at the time—a horrendous loss of life, but far from the near-extinction of humanity that occurs in *Earth Abides*. Likewise the vampire-like symptoms that afflict the infected in Richard Matheson's 1954 novel *I Am Legend* and its multiple film adaptations bear at most very tenuous relationships to any "real life" infections.

Moreover, the extreme mortality rates and incredibly rapid demises of individuals exposed to the titular microorganism of *The Andromeda Strain* are not comparable to even the deadliest terrestrial diseases. The suggested cause for that fictional microorganism's deadly effects on humans was that it produced "disseminated intravascular coagulation" (DIC). This term (roughly) means "blood clots form in vessels throughout the body." DIC is an actual condition associated with infections, severe injuries, and other causes. However, while certainly serious, in real-life medicine DIC is by no means uniformly fatal and certainly not nearly instantaneous in its effects, including death.

A potential "advantage" that science fiction has over using only known types of infectious (and other) diseases is that the writer has some flexibility in depicting how an imagined one is transmitted, the effects it has on humans, and other characteristics based on the story's plot. Thus, in *The Andromeda Strain* the pathogen was highly contagious but did not reproduce under very specific physiological conditions in humans—points critical both to how dangerous it was and how it was ultimately contained.

Another issue is whether an alien microorganism could actually cause disease in a human, or if a terrestrial variety could do that to an alien. For obvious reasons this question cannot be definitively answered at present. However, based on general biological principles the likelihood of this happening would overall seem extremely low. Despite the obvious differences among all the myriad life forms that have evolved on Earth they share many characteristics at the atomic and molecular level. As described in Chap. 1, these include use of similar DNA and RNA, only the left-handed type of amino acids, and a range of specific varieties of proteins, carbohydrates, lipids, and many other substances.

Life originating in another star system might be based on variations of at least some of these general categories of chemicals. However, it is most likely that at least some of the *particular* ones used by the alien equivalent of bacteria and other pathogens would be dissimilar enough from terrestrial types to be incapable of causing infection in humans.

On Earth pathogens are generally specific for the cells and metabolic environments of particular species. Harmful microorganisms can sometimes cross species, such as the way HIV is thought to have spread from other primates to humans. However, the biological dissimilarity between terrestrial animals and alien ones would be expected to be far, far greater. Moreover, many bacteria such as the normal "gut flora" we possess or the adeno-associated virus that will be discussed in Chap. 12 can infect us but do not actually cause disease. Thus, even if an alien microorganism entered our bodies it might not only do no harm but die of starvation due to our biochemical pathways being too different from it to allow it to "feed" off or do anything else with us. On the other hand, if these organisms were somehow able to survive within us, potentially they could cause harm by producing substances toxic to us as part of their life processes without actually causing an infection.

Compared to the potential risks posed by unearthly bacteria, those from an extraterrestrial virus seem even lower. Unlike bacteria, all viruses are pathogens. They cannot reproduce on their own and need to take over the resources of a cell to do that. Viruses are basically a protected strand of DNA or RNA. Here too, however, a virus would need to be genetically and biochemically compatible enough with the cell it infects to replicate and cause an infection. Also, a virus could not develop and reproduce in the absence of cells. If the latter have significant biochemical and other differences from our cells, the viruses that infect those alien ones will not be able to do the same to ours.

Viruses are considered to be at the boundary between living and nonliving things. Still simpler infectious agents, prions, are considered nonliving but can cause diseases in humans, such as bovine spongiform encephalopathy (aka "mad cow disease") and kuru. Prions consist only of protein, without DNA or RNA. They can damage the brain as part of their replication process. However, whether prions could develop in an extraterrestrial environment, much less whether they could do so in a way to make them infectious, is highly speculative.

A potential exception to alien microorganisms being most likely "benign" is that any microbial life elsewhere in our own Solar System might at least somewhat resemble the terrestrial variety. As noted in Chap. 1, Earth's organisms' exclusive use of left-handed amino acids might be due to physical conditions associated with our Sun and its development, and thus could also apply to life developing on its other worlds.

For example, one theory for the origin of life on our world is that it first evolved on Mars roughly 4 billion years ago when the Red Planet briefly (in geological terms) might have had enough liquid water on its surface and other "ingredients" for life to originate there. Thus, if those microorganisms (or at least the chemical precursors needed for later development of life) arrived on Earth from Martian rocks blasted into space by large asteroid impacts, any present-day microbes on Mars might be somewhat similar to their distant "descendants" on our world. However, despite some possible chemical similarities those Martian "bacteria" or "viruses" would never have had the opportunity or the necessity to adapt themselves in ways that could either infect humans or cause disease. Still, the remote possibility that future astronauts could bring back hostile (though microscopic) invaders back from Mars to Earth is at least being seriously considered [7].

Another type of "infection" sometimes depicted in science fiction is the idea that intelligent alien organisms could either act as parasites to control our minds or symbiotes to enhance their hosts in some way. Examples of the former include the slug-like aliens in Robert A. Heinlein's 1951 novel *The Puppet Masters*, the "ear worms" used by Khan for mind control in *Star Trek II: The Wrath of Khan* (1982),[1] and most of the Goa'uld from the *Stargate SG-1* television series, while the humanoid Trill in the later *Star Trek* series meld with their hosts in a more benign relationship.

However, any alien organisms planning to "tap into" the human brain by attaching themselves to our central nervous systems would face formidable biological challenges. Besides issues regarding compatible amino acids, proteins, etc. described previously, the human body has a strong system for rejecting foreign material that enters it. Transplanted organs like kidneys and livers must be "matched" closely with the recipient to make sure they share as many different important "antigens" as possible that help the body decide what belongs in it and what does not. Having more such similarities reduces the chance the recipient's immune system will identify the new organ as "foreign" and try to destroy it. An alien organism living near or under the skin on one's back would be expected to be a red flag to a person's immune system that something is very much amiss.

The feasibility of creating an interface between the alien's nervous system and a human's would also be questionable. It would require many extensive connections between two entirely different sets of cells working in a highly coordinated manner throughout both the alien's and human's central nervous systems. Worse, the biological "circuitry" involved would have to carry two-way information well enough to allow one mind to control the other or for a "blending" of minds. Considering the formidable challenges of trying to do something this extensive between two human brains (a subject for later chap-

[1] The drama of the scene in which Commander Pavel Chekov and Captain Clark Terrell are "infected" by the alien organisms can overpower the biological questions it raises about how exactly those "worms" actually exert their will-numbing effects on their hosts. Once placed in the latter's external auditory canals, do those creatures whisper Khan's commands to the Starfleet officers? Less facetiously, do they secrete a substance that could reduce a human's ability to think for himself? Hopefully they do not actually burrow directly into the victim's brain. This would not only require rupturing the tympanic membrane ("eardrum") and destroying the delicate anatomical structures in the middle and inner ears, leaving the individual deaf on that side, but would also cause significant, irreversible damage to the cerebral cortex. The worm would also have to traverse a comparatively long distance through that cortex to presumably reach one or both frontal lobes, the parts of the brain most associated with volitional activity. Maybe it's better not to think too deeply about such things and just enjoy the movie…

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